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Canadian Science Advisory Secretariat
Maritimes Region | Science Response 2018/020

STOCK STATUS UPDATE OF ATLANTIC COD (*GADUS MORHUA*) IN NAFO DIVISIONS 4X5YB

Context

Although Atlantic Cod (*Gadus morhua*) in Northwest Atlantic Fisheries Organization (NAFO) Divisions 4X5Yb (herein referred to as 4X5Yb Atlantic Cod) have supported a commercial fishery since the 1700s, their abundance has declined in number and biomass since 1980. In 2003, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Maritimes Designatable Unit (DU) of Atlantic Cod as Special Concern (COSEWIC 2003). In 2010, COSEWIC split the Maritimes DU into two new DUs, the Laurentian South DU and the Southern DU, including NAFO Divs. 4X5Yb, and re-assessed the Southern DU as Endangered due to significant decline in abundance and evidence of an unexplained increase in natural mortality in NAFO Div. 4X (COSEWIC 2010).

A Recovery Potential Assessment (RPA) was carried out by Fisheries and Oceans Canada (DFO) Science in 2011 to provide the information and scientific advice required to meet various requirements of the Species at Risk Act (SARA). The RPA used data (1980-2008) from the most recent peer reviewed stock assessment (DFO 2009) to explore the consequences of particular productivity assumptions and catch scenarios (DFO 2011a). The next framework for 4X5Yb Atlantic Cod is scheduled for 2018, with the Data Inputs meeting occurring in March 2018, followed by a Modeling framework tentatively scheduled for Fall 2018. The last 4X5Yb Atlantic Cod stock status update was conducted in 2016 (DFO 2017a) and the present Science Response is the result of a request for a stock status update from Resource Management (Maritimes Region) using the most recent DFO Summer Research Vessel (RV) surveys (2016-2017) and fishery landing data up to 2016.

This Science Response Report results from the Science Response Process of December 4, 2017, on the Stock Status Update of 4X5Y Cod.

Background

Atlantic Cod is a bottom dwelling North Atlantic fish that ranges from Georges Bank to Northern Labrador in the Canadian Atlantic, including the southern Scotian Shelf and Bay of Fundy (NAFO Divs. 4X5Yb) (Figure 1).

Canada

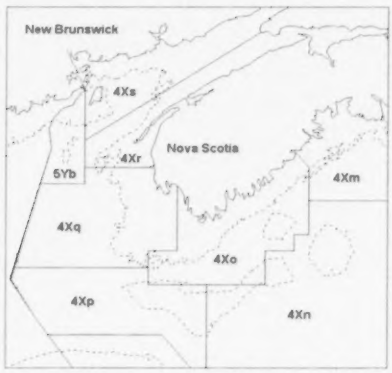

Figure 1. Northwest Atlantic Fisheries Organization (NAFO) Divisions 4X5Yb.

Atlantic Cod in Divisions 4X5Yb are caught as part of a mixed species fishery that includes Haddock (*Melanogrammus aeglefinus*), Pollock (*Pollachius virens*), Winter Flounder (*Pseudopleuronectes americanus*), redfish and other species. Landings increased in the 1960s as domestic and foreign otter trawl fleets joined the fishery, and then landings dropped in 1970 due to restrictions on Haddock fishing. Total landings averaged 20,000 tonnes (t) for several decades, but have declined along with restrictive Total Allowable Catch (TAC) (Figure 2). In 2016 landings amounted to 717 t; a slight increase from the series low of 705 t in 2015. Currently, Atlantic Cod are caught primarily as a bycatch species in groundfish fisheries.

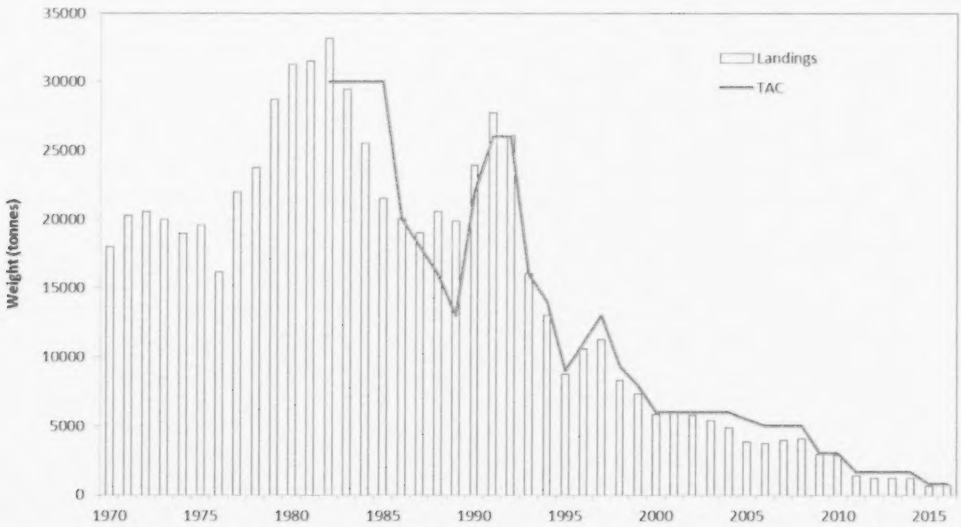

Figure 2. Landings and Total Allowable Catch (solid red line) for 4X5Yb Atlantic Cod by quota year.

The most recent stock assessment (2008) showed that the stock had declined in abundance since the early 1990s and revealed a trend of continuing decline (DFO 2009). Natural mortality was estimated to be unusually high for Atlantic Cod aged 4 years and older (0.76 for 1996-2008) and average recruitment had declined to less than half of the pre-1992 level. A

conservation Limit Reference Point (LRP) was calculated for the Spawning Stock Biomass (SSB) based on a Beverton-Holt stock recruitment model as B*lim* = 24,000 t and the target fishing mortality (F*ref*) was 0.2. At the time, the SSB was estimated based on a Virtual Population Analysis (VPA) model to have been below the LRP since 2002. The most recent estimate of SSB was 10,600 t at the beginning of 2009.

Annual fishing mortality (F) has been variable and high, ranging between 0.4 and 0.5 in the 1980s, rising to a peak over 1.0 in 1991, then declining to lower levels. From 1995 to 2008, F was above the reference level 0.2, ranging between 0.2 and 0.4 (DFO 2011a). In 2011, following science advice provided in the RPA, the TAC was reduced by 45% to 1650 t; a fishing level expected to result in approximately F=0.11, or 55% of F*ref*. This value was deemed to meet the rebuilding requirements and prevent further decline in biomass, and to balance rebuilding requirements with socioeconomic considerations. The TAC remained stable at 1650 t from 2011-2014. Due to information presented in the 2014 update (DFO 2015), the TAC was further reduced by 50% to a total of 1650 t over two years (2015/16 and 2016/17), with a carry-forward of no more than 15% of final quota amounts between two-year quota periods. The same arrangement was renewed for the 2017/18 and 2018/19 years, maintaining TAC at 1650 t over two years.

The VPA formulation from the most recent stock assessment estimated natural mortality (M) for Atlantic Cod Age 4+ as 0.76 from 1996 to 2008, which is much higher than the value of 0.2 historically used as an estimate of M at all ages for Atlantic Cod. Major sources of mortality for the stock are natural mortality, fishing discards and bycatch. The possibility that a change in the emigration rate of Atlantic Cod from 4X5Yb has contributed to declining survey trends has not been fully assessed, although the fact that adjacent stocks are also very low and/or declining suggests that this is unlikely.

Analysis and Response

Survey station coverage and Atlantic Cod catches from the 2016 and 2017 annual DFO Summer RV Survey are shown in Figure 3. Details of survey design and 2016 results are available in the survey report (DFO 2017b).

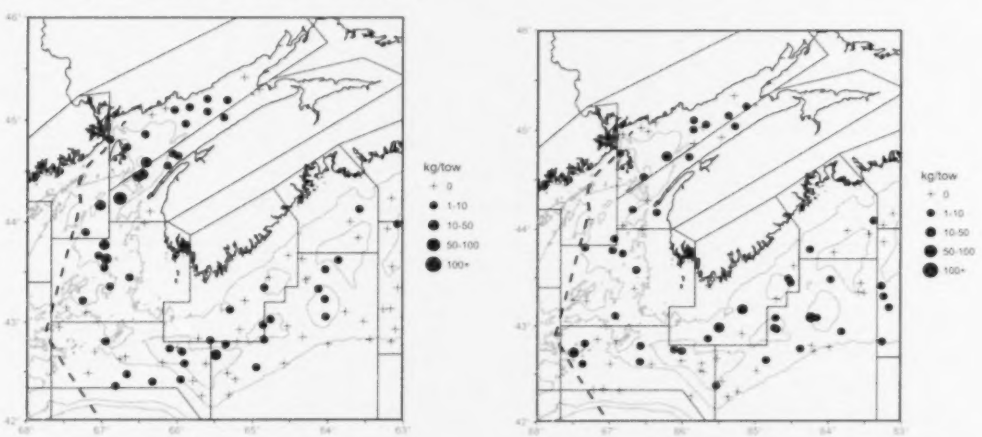

Figure 3. Distribution of Atlantic Cod catches during the 2016 (left) and 2017 (right) DFO Summer Research Vessel Surveys in 4X5Yb. Zero catch is represented by the + symbol. Black circles represent catches. The circle area is proportional to the catch size. Blue lines represent survey strata areas and black lines represent NAFO unit areas.

In 2017, Atlantic Cod survey biomass was 3068 t, which is above the series low seen in 2013 (2058 t), but it remains among the lowest in the time series (Figure 4). The trends in total (Age 1+) and adult (Age 3+) biomass estimates from the most recent VPA model run (DFO 2009) generally track the survey biomass index, particularly for the past two decades of declining abundance (Figure 4). The high survey index in 2009 appears to have been anomalous relative to the declining trend of the stock. The trend in the survey biomass index suggests that the stock has been gradually declining since the 1990s, and it has stabilized at a low level since 2010 (Figure 4). This stock was assessed as being in the Critical Zone during the 2011 RPA (DFO 2011a, Clark et al. 2015) and has shown no signs of recovery since then.

Figure 4. Scaled biomass index of Atlantic Cod in 4X5Yb from the DFO Summer Research Vessel survey from 1970 to 2017. Age 1+ and Age 3+ Virtual Population Analysis scaled biomass estimates from 1980-2008 are also shown (DFO 2011a). The red dotted line represents 15-year scaled average (2003-2017), and the green solid line represents 5-year scaled average (2013-2017).

In general, the instantaneous rate of fishing mortality calculated from the VPA tracks variation in relative fishing mortality (relF) (Figure 5). Relative fishing mortality declined around 1994 and has remained relatively low throughout the 2000s. As a result of recent TAC decreases and relatively stable survey biomass indices in recent years, the 2016 relF is the lowest in the time series (Figure 5). Overall, the total mortality (combination of natural mortality, mortality from reported fishery landings and discards, unaccounted for mortality, and fish emigration) of Age 4 and 5 (Z4-5) has been quite variable over the time series. However, this variability has increased since 2003, with values ranging from -0.06 to 2.78 (Figure 5). Moreover, there have been very few Atlantic Cod older than Age 5 in survey and fishery catches since 2010 (Figure 6), which suggest that natural mortality of Age 4+ Cod remains elevated or has further increased.

Figure 5. Relative fishing mortality (relF), instantaneous fishing mortality from the most recent Virtual Population Analysis model run (VPA F) and total mortality from annual DFO Summer Research Vessel survey catches-at-age (Z4-5). Virtual Population Analysis F is for Ages 4-5 and relF is based on landings/survey biomass.

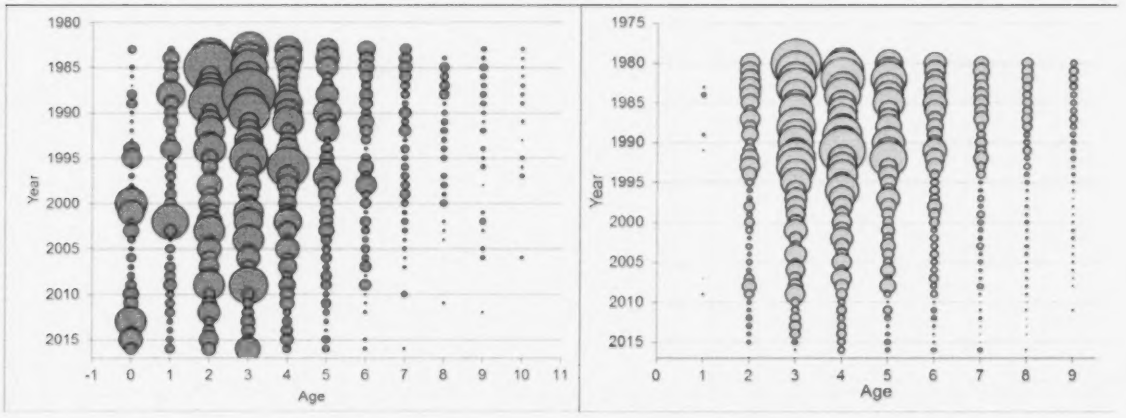

Figure 6. DFO Summer Research Vessel Survey indices-at-age (left, 1970-2016) for 4X5Yb Atlantic Cod and fishery catch-at-age (right, 1980-2016). The size of the bubble is proportional to the number-at-age.

The unexplained increase in mortality in the mid-1990s has been observed in other Atlantic Cod stocks (e.g. TRAC 2016). The reason for the elevated rate of mortality in this and other stocks is not fully understood; however, it may include but not be limited to:

- Predation by seals. The Canadian Grey Seal (*Halichoerus grypus*) population continues to increase at approximately 4% per year (DFO 2017c).
- Un-estimated discarded bycatch from other fisheries (Gavaris et al. 2010, Pezzack et al. 2014).

The Age 1 recruitment index for 2016 is comparable to those seen during the 2000s but remains low relative to the earlier period (Figure 7). There has only been one strong year class (2001) seen since 1995, which is a contrast to the higher frequency of strong year classes seen prior to 1995 (Figure 7).

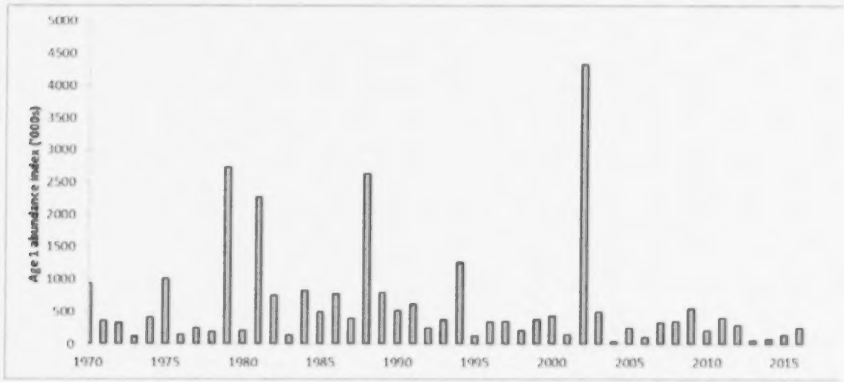

Figure 7. Age 1 recruitment index from DFO Summer Research Vessel Survey.

The stratified total estimates of Atlantic Cod abundance by length in 2015, 2016 and 2017 were well below the average from 1970-2016, except for Atlantic Cod less than 10 cm (Figure 8). These small fish (likely Age 0) were very abundant in 2015 and close to the long term average in 2016 and 2017. The high abundance of Cod under 10 cm in 2015 did not persist as higher abundance was seen at larger Cod sizes in 2016 and 2017.

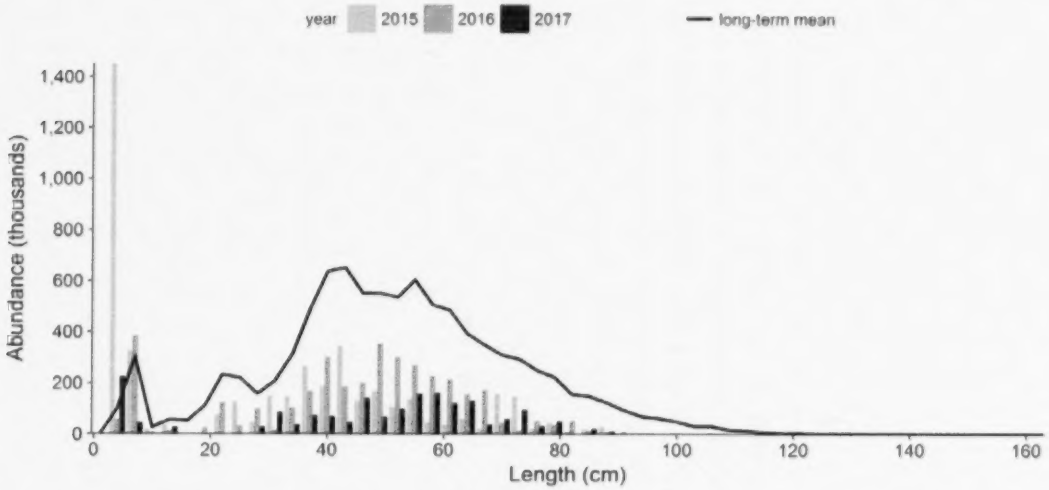

Figure 8. Length frequency indices for Atlantic Cod in 4X from the DFO Summer Research Vessel Survey. Bars represent the number in thousands at length from the 2015 (grey), 2016 (red) and 2017 (black) surveys. The solid black line represents the average number in thousands at length for the time period 1970-2016.

Conclusions

The survey biomass index has remained at a very low level since 2010. The recruitment index for this stock has also remained low in recent years, with the 2013 value being the second lowest on record. Although the survey length frequencies suggest that the abundance of Age 0 Atlantic Cod was well above average in 2015, this high abundance was not observed for Age 1 in 2016 or Age 2 in the 2017 surveys.

Recent assessment work on adjacent Eastern Georges Bank, Eastern Scotian Shelf, Southern Gulf of St. Lawrence, and Gulf of Maine stocks confirm that productivity has been unusually low due to persistent low recruitment and high total mortality across the entire area (DFO 2011b, Mohn and Rowe 2012, Palmer 2014, Swain et al. 2012, TRAC 2016). In 4X5Yb, total mortality of Age 4+ Atlantic Cod was elevated from 2009 to 2016.

Given the very low biomass, low productivity due to low recruitment, truncated age structure and high total mortality, the current outlook for this stock is extremely poor. This stock was concluded to be in the Critical Zone in the 2011 RPA (DFO 2011a, Clark et al. 2015) and the biomass index has remained at this low level since then. In keeping with the Precautionary Approach (DFO 2006), landings should be kept as low as possible while the stock is in the Critical Zone

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